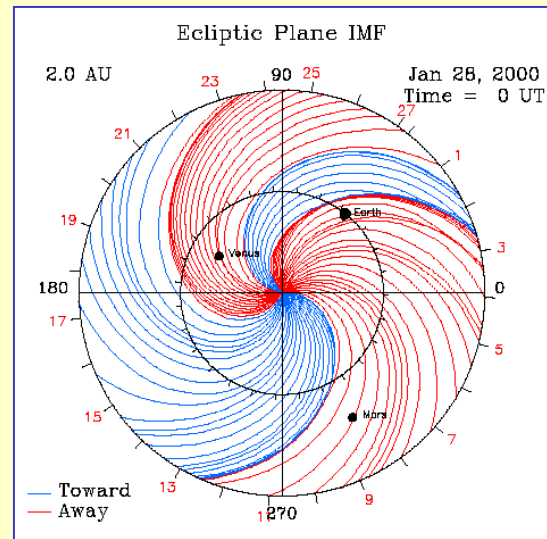
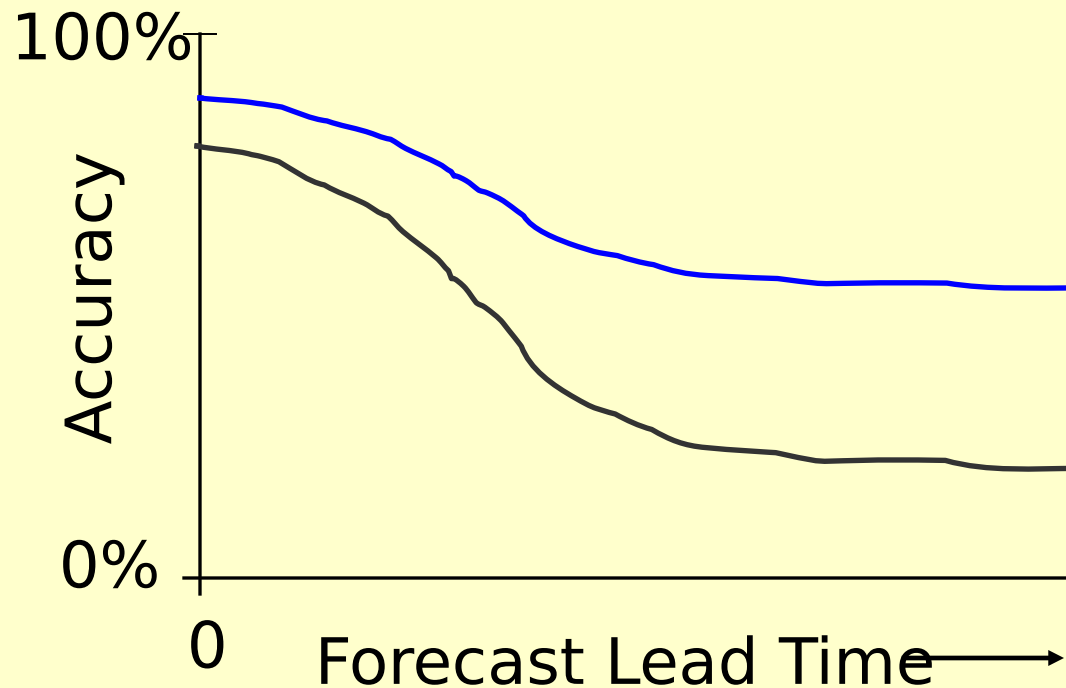


HAF: An Operational, Event-driven Solar Wind Forecast Model

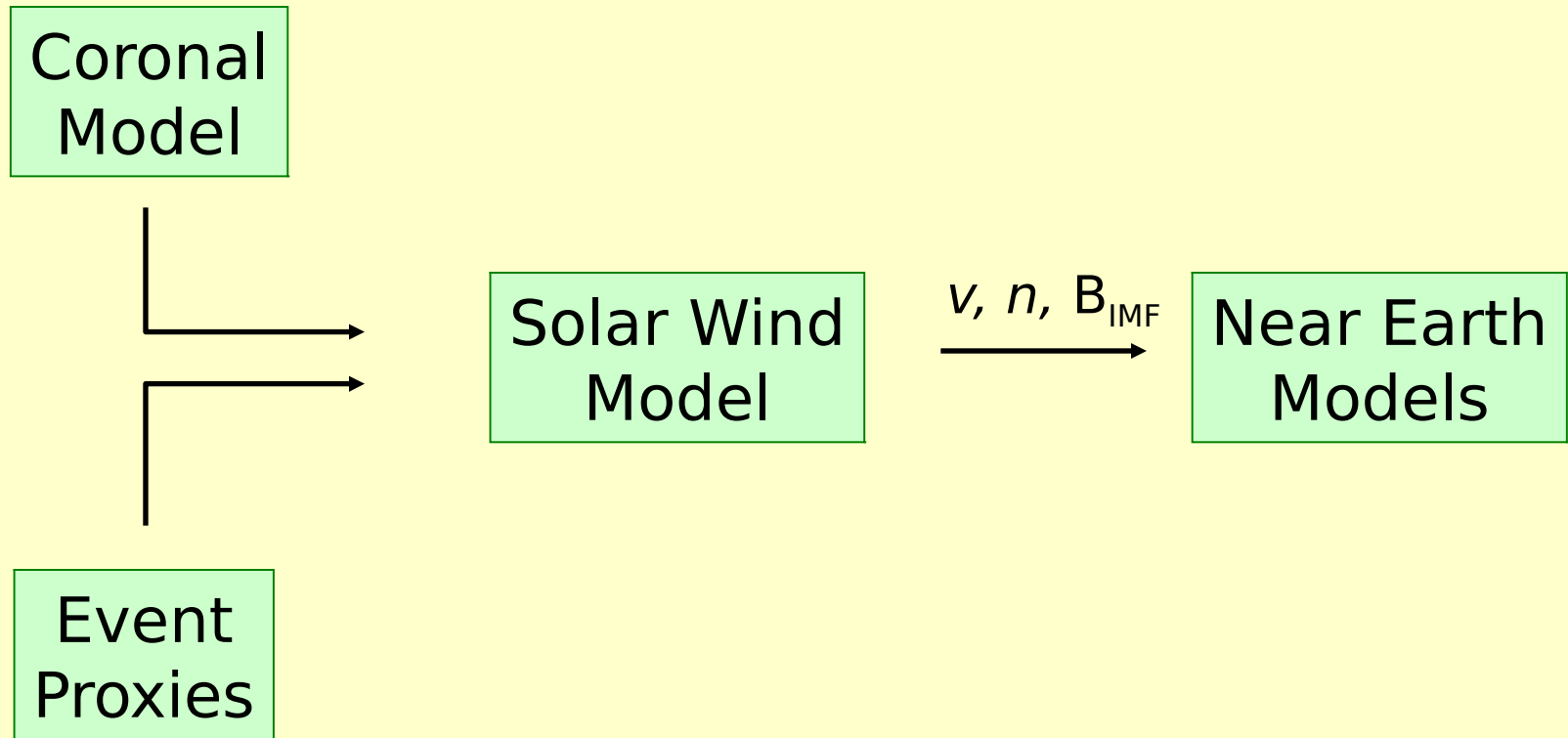
Murray Dryer
murray.dryer@noaa.gov



Goal: Improve Space Weather Forecasting



Geomagnetic Storm Prediction System



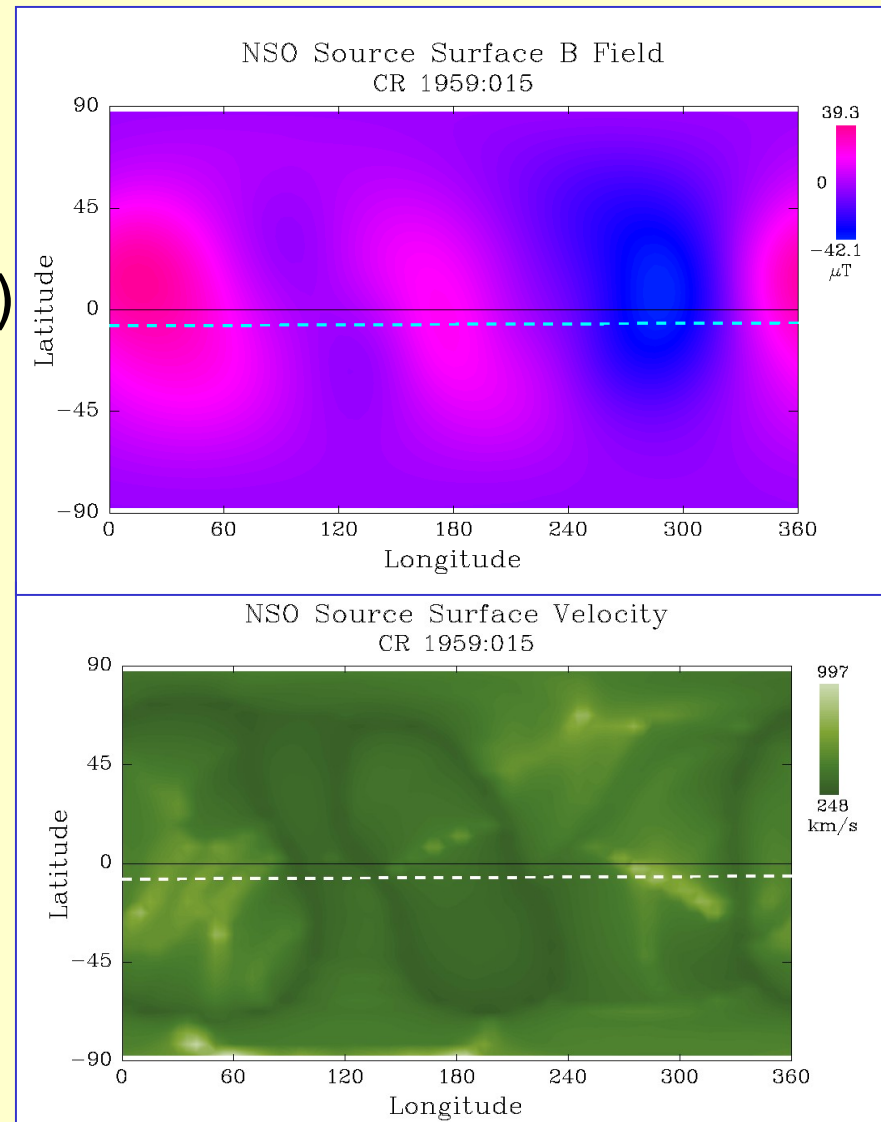
HAF Model Inputs: Ambient Solar Wind

Steady State:

- Source surface (2.5 Rs)
- B , v synoptic maps

Maps from:

- SEC (*Arge* & *Pizzo*)
- Solar observatories (NSO, MWO, WSO)



HAF Model Inputs: Solar Events

Required Input	Observation
Start time eg., 20010825 1642	GOES X-ray or metric type II radio event start time
Location, eg., N20 W34	H-alpha or active region report
Initial shock speed, V_S	Metric type II radio report or spectra
Duration, τ	GOES X-ray flux temporal profile



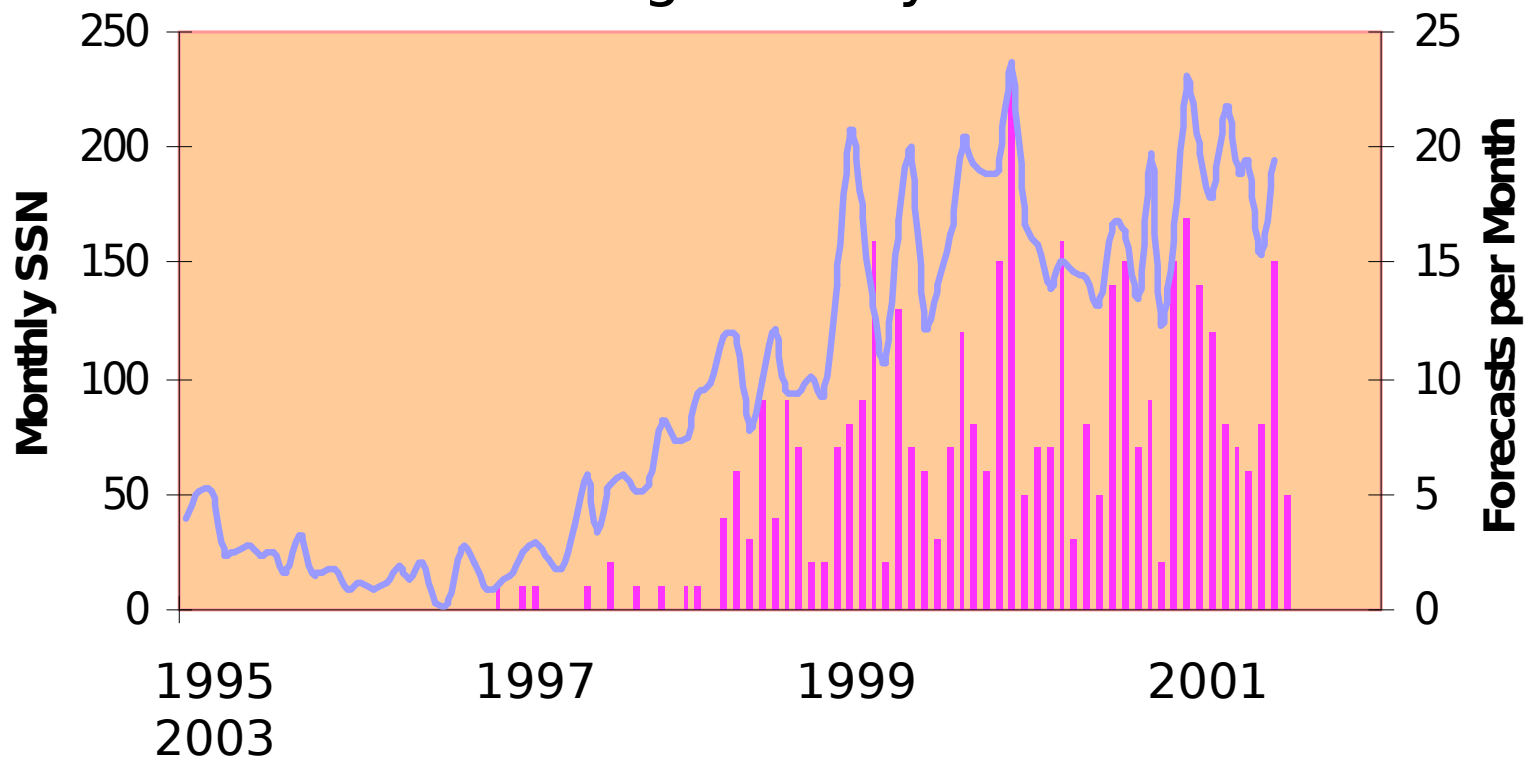
“Fearless Forecast” Study

- NOAA/SEC, EXPI, GI/UAF
- February 1997 - present
- Interplanetary shock arrival time (SAT) at Earth
- Ensemble of three models (HAF, ISPM, STOA)
- Benchmark forecast skill



“Fearless Forecast” Study

Shock Arrival Time Forecasts During Solar Cycle 23



“April Fools Day” 2001 Events

Events

<u>FF#</u>	<u>Start date/time</u>		<u>Vs</u>	<u>Location</u>	
<u>Comment</u>					
254	20010327	1632	677	N22 E33	M2.2/1N
255*	20010328	1240	1000*	N18 E02	M4.3/SF
256	20010329	1004	1300	N16 W12	X1.7/1N
257*	20010330	1559	1850	S10 W90*	Blowout?
258*	20010330	1620	1600	S10 E115?	Blowout?

Forecast #256 issued 29 March 2001, 2055 UT

HAFv.2: Shock will overtake the two previous interplanetary ICMEs, and the combined structure's **shock will arrive at 1800 UT, 30 March 2001.** SSI = 1.0, and delta(dynamic pressure) = 13.2 nPa.



“FF” #255-258, issued Mar. 28-30, 2001

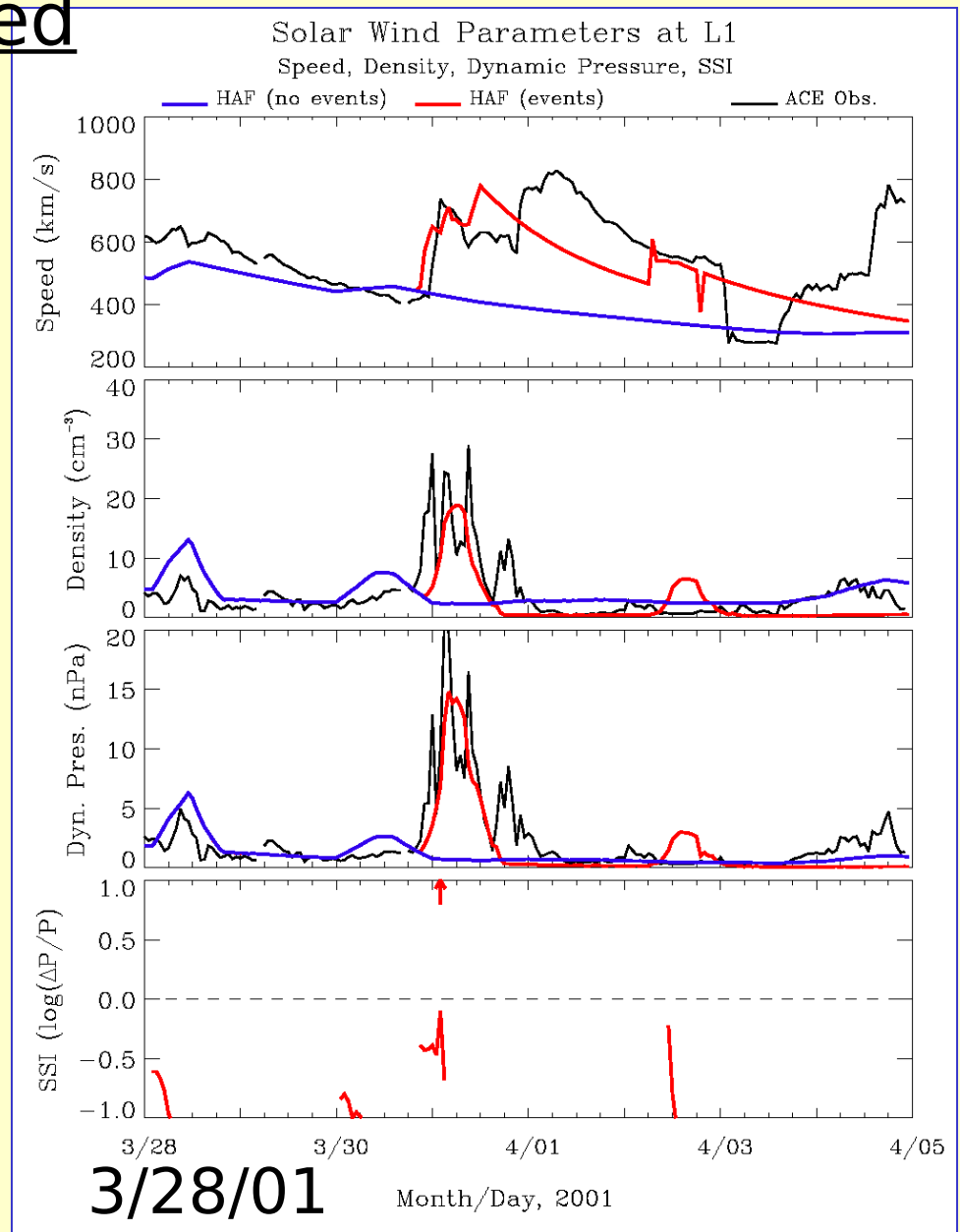
Speed

Density

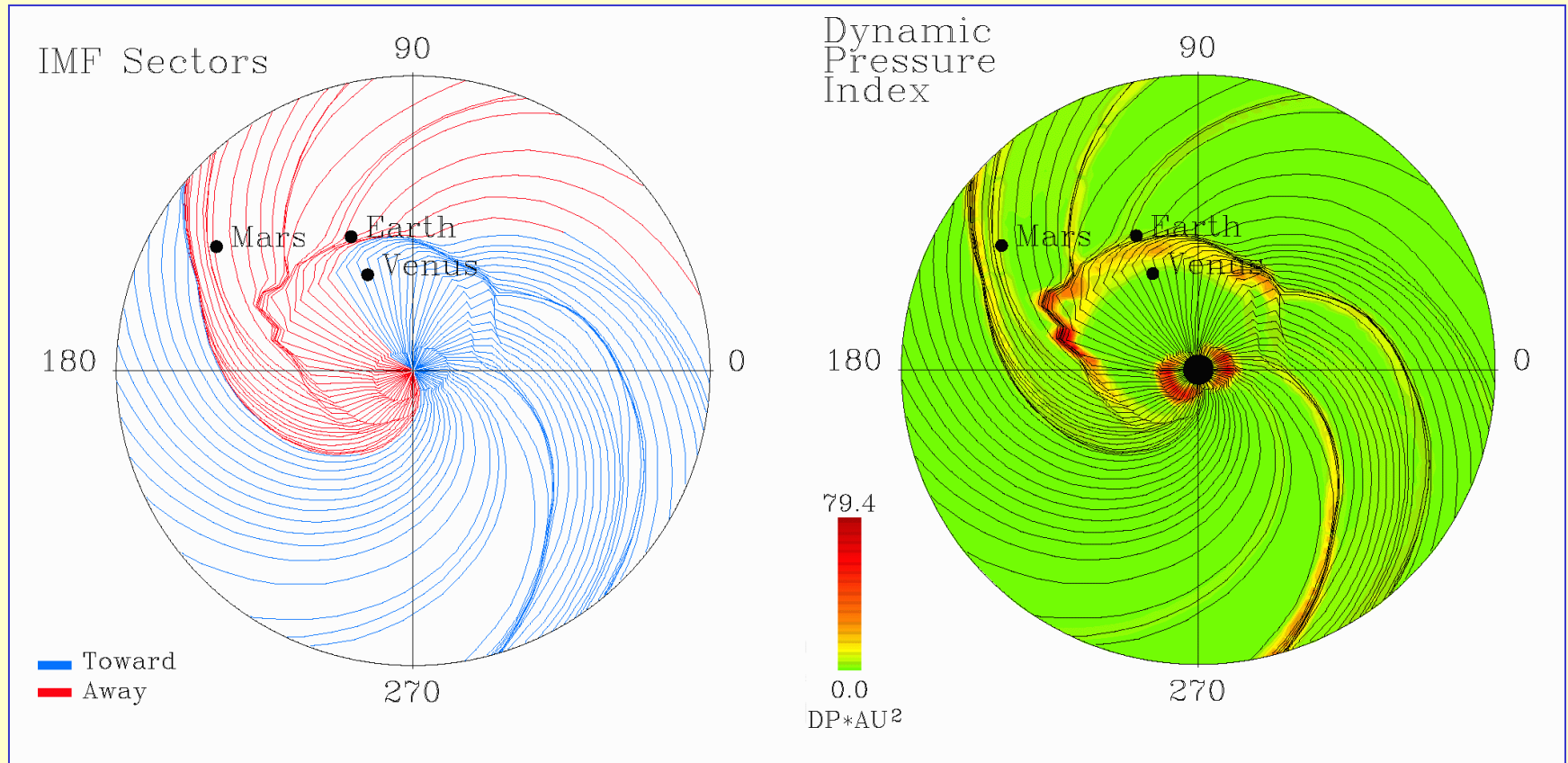
HAF Model
Prediction

Dynamic
pressure

$\text{Log}(\Delta P/P)$



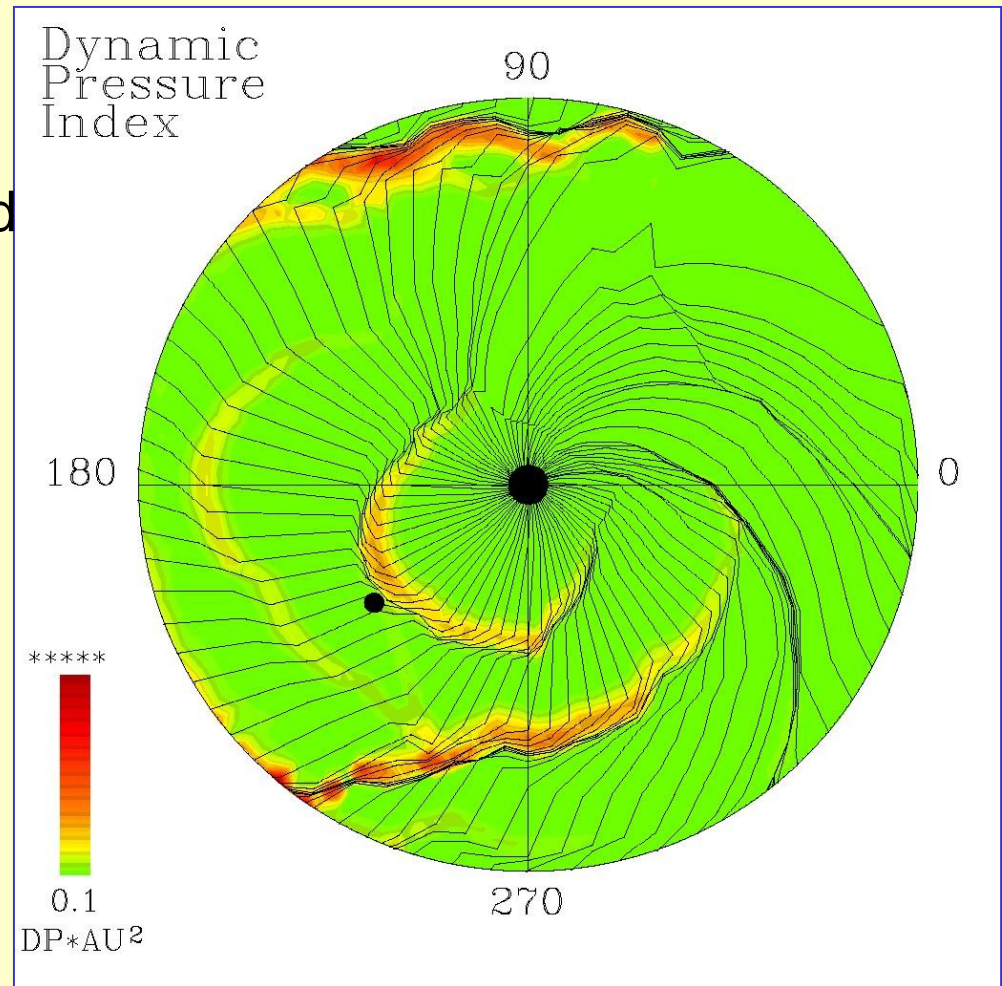
“April Fools Day” 2001 Event



“Bastille Day” 2000 Event

“Fearless Forecast” issued
at 20:31 UT
on July 14, 2000:

“Strong shock will arrive
at 15 UT
on July 15, 2000.”



[Dryer et al., *Solar Phys.*,
2001]



Exploration Physics International, Inc.

“Fearless Forecast” Metrics

Contingency Table

	Observed	
	Yes	No
Forecast	Yes	No
Yes	<i>hit</i>	<i>false alarm</i>
No	<i>miss</i>	<i>correct null</i>



“Fearless Forecast” Metrics

Feb. 1997 - Oct. 2000

173 events, 68 observed shocks

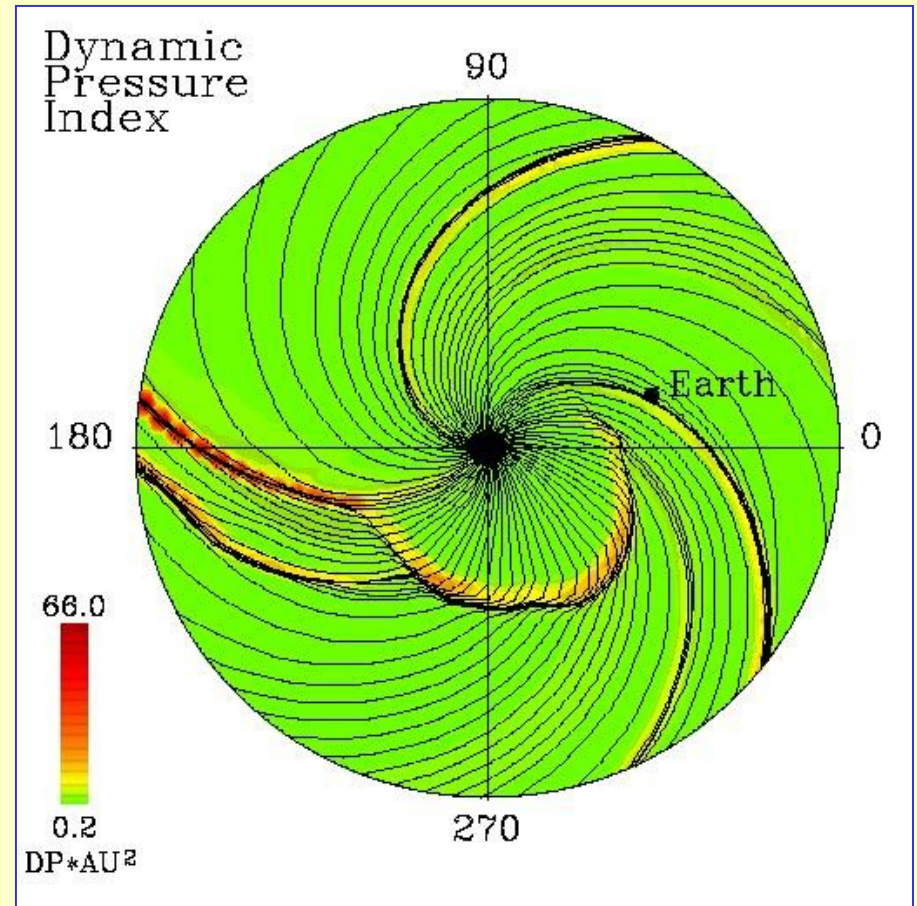
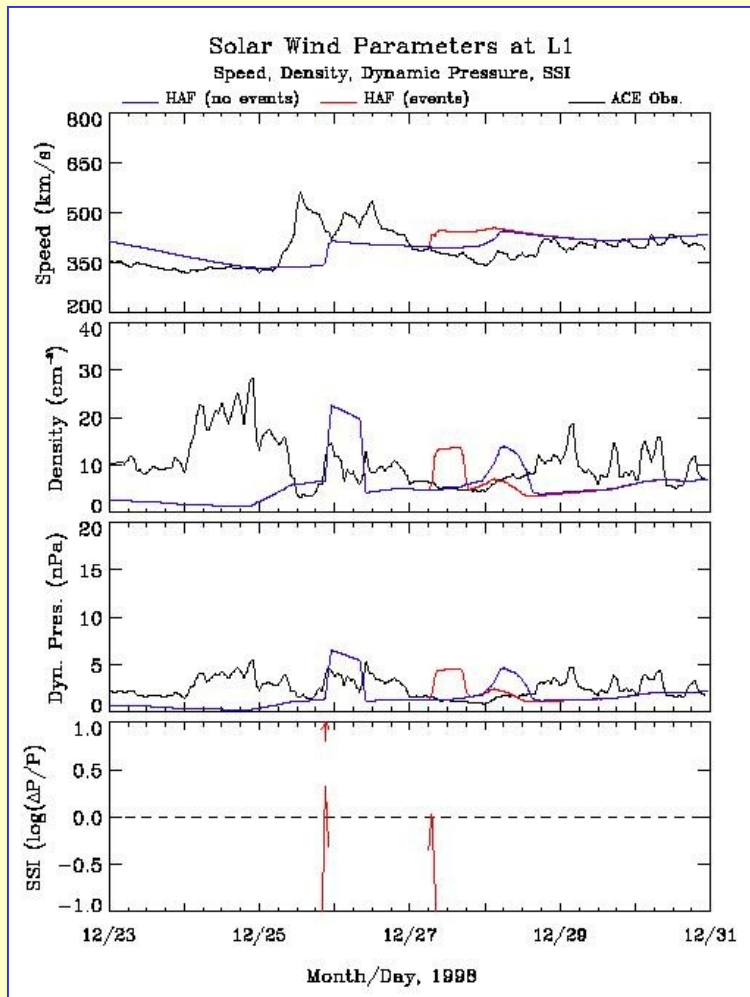
- Success rate > 50 %
- False alarm rate ~ 50%
- Hit/Miss Ratio STOA best for strong shocks
HAF best for medium, weak shocks
- Heidke skill score ~ .15 - .20
- RMS error ΔT ($SAT_{\text{PRED}} - SAT_{\text{OBS}}$) ~ 11 - 12 hours



Solar Cycle 23 - Lessons Learned

- CIRs produce shocks.

Dec. 25, 1998, 20 UT



Solar Cycle 23 - Lessons Learned

- Initial shock speed is the most important input to the SAT prediction.
- SAT forecast skill is best near Central Meridian.
- SAT forecast skill is worst for limb events low because Metric Type II speeds are too



Future of Operational, Real-Time, Sun-to-Earth Solar Wind Predictions

Better Customer Collaboration:

- Specify Needs

+

Improved Forecast Skill:

- Assimilate Data
- Predict B_z

=

Increased Customer Support:

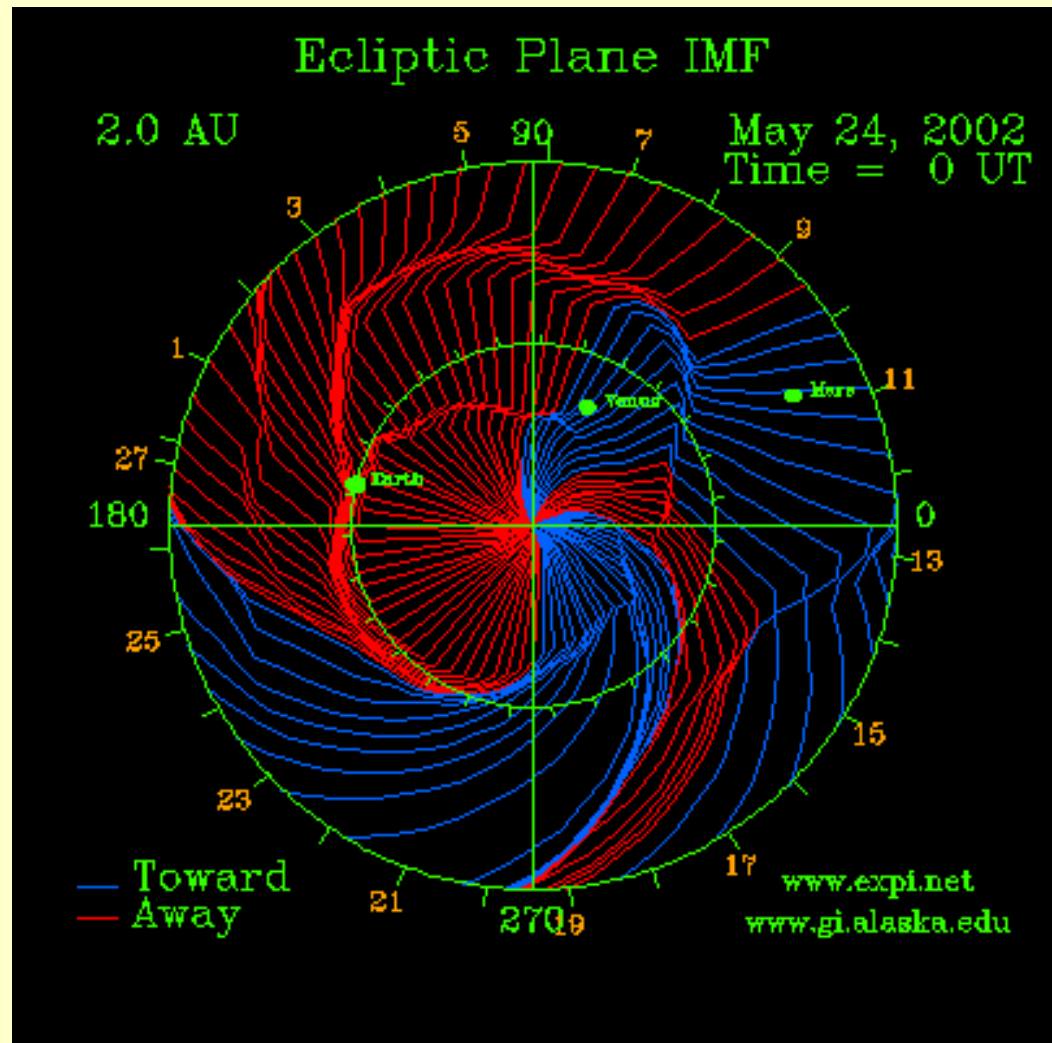
- Make Advanced Operational Decisions



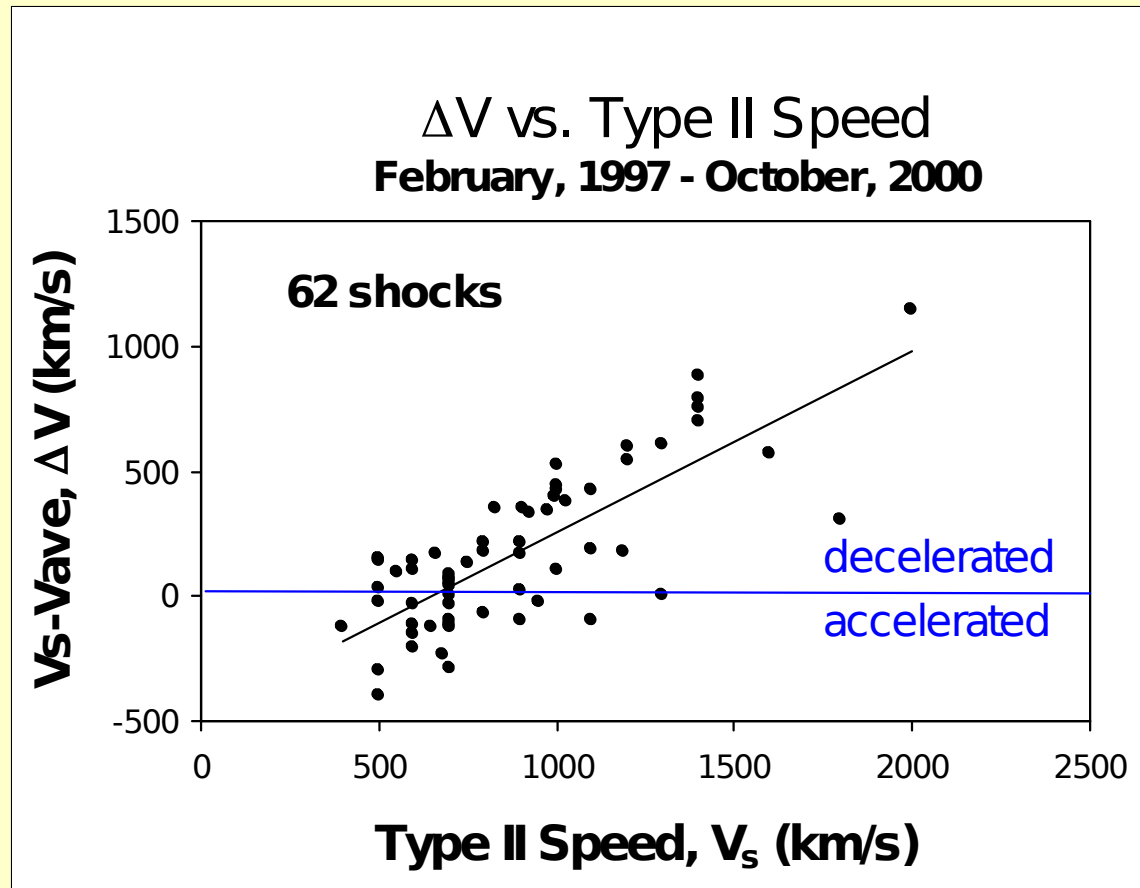
“Fearless Forecast” Web Site

<http://gse.gi.alaska.edu>

Email: gfry@expi.com



Metric Type II Speed



Hakamada-Akasofu-Fry (HAF) Solar Wind Model

- Provides realistic background and event-driven solar wind conditions at L1 and elsewhere.
- Takes in solar observations and event reports.
- Uses “modified kinematic” approach to track solar wind fluid parcels.
- Predicts interplanetary shocks in the global heliosphere.
- Drives downstream empirical and first-principle space

